The effect of neighborhood size and regularity on reading Chinese in Hong Kong children

Wong Hiu Lam Grace

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Abstract

The effect of neighborhood size, with target constituent characters either in the initial or second position, and regularity was investigated to study the lexical processing of Chinese compound words in Hong Kong primary graders. The result showed facilitative neighborhood size effect on naming accuracy in the third-, fourth-, and fifth-graders. Inhibitory effect was also evident in the fifth-graders, when the neighborhood size interacted with the position and regularity of the target constituent characters. It was hypothesized that the threshold for neighborhood size and the competition between the regularity effect and the neighborhood size effect at different levels in the mental lexicon determines how the neighborhood size contributes to the naming accuracy. The changes across grades suggested more pronounced lexical competition in the older children.

Introduction

There have been a number of studies investigating how neighborhood size and frequency play a role in word recognition and lexical access. Most of the studies were based on the concern on how lexical representations are involved and activated in the mental lexicon during the lexical access in reading.

For alphabetic languages, Coltheart, Davelaar, Jonasson, and Besner (1977) proposed the use of N metric to define neighbor, by counting the number of words that can be formed by changing one letter of a target word. The study found that neighborhood size effect was only significant in nonwords instead of real words in a lexicon decision task. The null effects of neighborhood size on real words reported in Coltheart et al.'s (1977) study might be attributed to the fact that stimuli which were not categorized by word frequency (Andrews, 1997; Tsai, Lee, Lin, Tzeng & Hung, 2006). In this case, the neighborhood activation might contribute relatively less on lexical decision. Contrary to Coltheart et al.'s (1977) study, later studies provided a lot of evidences for the facilitative effect of neighborhood size in both lexical decision tasks and naming tasks (Andrews, 1989, 1992; Sears, Hino & Lupker, 1995). Words from large neighborhoods were responded to more quickly than words from small neighborhoods, and the neighborhood size effect was more facilitative in low frequency words than in high frequency words. It was explained by the activation models that word recognition for high frequency words tends to rely less on the contribution of neighbors than that for low frequency words (Andrews, 1997).

Among the prior investigations, the neighborhood size effect was mainly measured by the response latencies of normal adult readers in lexical decision tasks and word naming tasks (Coltheart et al., 1977, Andrews, 1989, 1992, Sears et al., 1995, Carreiras, Perea & Grainger, 1997, Zhang & Peng, 1992, Tsai et al., 2006). Few studies

addressed the neighborhood size effect on reading in typically-developing children. Facilitative effects of neighborhood size on word recognition have been reported for children's naming accuracy in English-speaking population (Laxon, Coltheart, & Keating, 1988). Findings on Cantonese-speaking population, however, were lacking. It would be interesting to investigate what role does neighborhood size effect plays in the reading of school-aged children, and how does the effect develops across ages. It would give implication on how the involvement of neighboring words contributes to the activation of target word in the mental lexicon of primary graders.

Unlike alphabetic script, compounding is a common way to construct new words in Chinese. Most of the Chinese words are compound words which are composed of two or more constituent characters which usually correspond to morphemes, as for example, "手" (/sɐu$_{35}$/, meaning "hand") and "指" (/tsi$_{35}$/, meaning "pointing") are the initial and final constituent characters of the word "手指" (/sɐu$_{35}$/ /tsi$_{35}$/, meaning "finger") respectively. Chinese disyllabic compounds are about 73.6% by type and 34.3% by token in a large text corpus (Institute of Language Teaching and Research, 1986). It was stated that over 60% of two-character words have at least one neighbor, sharing a constituent character at the same position (Chinese word corpus of Academia Sinica Taiwan, 1998). Zhou, Marslen-Wilson, Taft, and Shu (1999) proposed a model for reading Chinese compound words, assuming that the morphological structure of Chinese compound words is used explicitly to assist mapping of visual input onto lexical representations. At the orthographic, phonological and semantic levels, the representations for compound words have much overlap with the representations for individual morphemes. The orthographic and phonological representations of compound words, in most cases, are simply concatenations of the forms of the corresponding constituent morphemes (Zhou et al., 1999). In the process of word recognition, the visual input of a compound word is

decomposed into small units, activating the orthographic and phonological representations of constituent morphemes, and semantic representations of both morphemes and the whole word.

A recent study (Tsai et al., 2006) investigated the neighborhood effects of Chinese compound words in lexical decision times and eye gaze durations. In that study, neighborhood size was defined as the number of two-character words sharing the same initial constituent character. The result was consistent with the previous studies done in alphabetic scripts like English. The lexical decision times tended to be faster for words with more neighbors than words with few neighbors. It also showed that facilitative neighborhood effects of Chinese compound words were more prominent for low frequency words than high frequency words. According to the results of the study, words sharing initial constituent character are concluded to be simultaneously activated in word identification.

In Tsai's (2006) study, the neighborhood size was defined as the number of compound words sharing only the same initial constituent character, while the neighborhood size effect was not investigated in compound words sharing the same character in the second position. According to Huang (2003), the influence of neighborhood size on lexical access might differ according to the position of the character within a compound word. The morphemic semantic competition was suggested to be stronger when the critical characters are in the first position, while critical characters at the second position will mean a weaker competition (Zhou et al., 1999). It was based on the characteristics of left-to-right and top-to-bottom processing in reading Chinese. The issue of whether compound words with large neighborhood size in the initial constituent characters, comparing with those with large neighborhood size in the second characters, lead to more morphemic semantic competition and affect reading performance is still in

question. To investigate such issue, this study will address on the relationship between the position of target constituent characters and neighborhood size effect on reading. If the initial constituent character is more critical to the lexical processing of a Chinese compound word, significant main effect of target constituent character position, with higher accuracy in words with target constituent characters positioned in the initial position, will be expected. The neighborhood size effect is also hypothesized to vary across the position of the constituent characters, with more salient effect expected in the initial position of the words. Based on such hypothesis, significant interaction between neighborhood size effect and target constituent character position will be predicted.

Another question of interest concerns the relationship and interaction between regularity effect and neighborhood effect on reading. In English, regularity of a word is determined according to whether it follows the grapheme-to-phoneme correspondences rules (or GPC rules) in pronunciation. A word is regular if its pronunciation follows the GPC rules. On the contrary, it is classified as irregular if its pronunciation deviates from the rules (Lee, Tsai, Su, Tzeng, & Hung, 2005). For Chinese, there are no GPC rules. The regularity of a Chinese character is defined as whether the pronunciation of that character is the same as that of its phonetic radical (Hue, 1992). For example, the character "謊" (/fɔŋ$_{55}$/, meaning "lie") is classified as regular because its pronunciation is the same as that of its phonetic radical "荒" (/fɔŋ$_{55}$/, meaning "barren"). The word "滑" (/wat$_{2}$/, meaning "slippery") is classified as irregular as its pronunciation is not identical to its phonetic radical "骨" (/kwɐt$_{55}$/, meaning "bone"). In studies of English word naming, word frequency was found to be interacting with word regularity (Seidenberg, 1985, Waters, Seidenberg, & Bruck, 1984). Seidenberg (1985) found that low-frequency regular English words were named faster than matched irregular words. Hue (1992) also extended Seidenberg's experiment to examine naming latencies for regular, irregular, and

unique Chinese characters varying in frequencies. Similarly, low-frequency unique characters were named more slowly than matched regular characters, but faster than irregular one. It implied that phonological information in characters was used in character naming. Analysis of errors indicated that subjects tended to make more errors on low-frequency inconsistent characters than matched consistent characters, with no significant difference observed for high-frequency characters. They were more likely to make mistakes and need longer time to name the inconsistent and irregular characters. The phonological information of the Chinese characters is proved to be activated in character naming. The result suggested that the competition occurring in activating the phonological information of irregular characters was due to the differences between the pronunciations of the characters and the phonetics of the characters (Hue, 1992). Although there is little evidence on the effect of the regularity of component characters in the naming of Chinese two-character compound words, such findings showed support for the hypothesis that regularity effect is present in naming of Chinese compound words. As increased competition evident in the activation of the pronunciation of irregular characters could affect naming accuracy, neighborhood size effect is hypothesized to be more prominent in words with regular characters than in words with irregular characters. It is because less competition is likely to occur in the activation of pronunciation of regular characters, causing less interference to the facilitation of neighborhood size on naming accuracy. Moreover, changes in the interaction of effects between neighborhood size and regularity across different grades are expected as the importance of regularity rules for character naming may vary in children of different grades.

The present study aims at examining the neighborhood size effect, with target characters positioned in either first or second position, and regularity effect of target character on word naming accuracy for Hong Kong children at different ages and

education levels. Investigations into the effects on reading performance across grades will give implications for whether the representations in mental lexicon and mechanism of lexical access differ across grades. In the present study, the neighborhood effects of two-character compound words will be examined in a word naming task, with manipulations on neighborhood size, the position and regularity of target constituent character. Based on the hypotheses, significant main effect of target constituent character position is expected, with higher accuracy in words with target constituent characters positioned in the initial position. For the neighborhood size, main effect is expected to show its facilitative effect on naming accuracy. The neighborhood size effect is predicted to interact with the target constituent character position, with more prominent neighborhood size effect occurring in the initial position of a word. Apart from this, the hypothesis also predicts significant interaction between neighborhood size and regularity, in which more significant effect is expected in words with regular characters than in words with irregular ones. Changes in the interaction effects across grades are also expected.

Method

Participants. 34 third-graders, 32 fourth-graders, and 30 fifth-graders from four normal primary schools in Hong Kong participated in the study. All of them were native Cantonese speakers with normal intelligence. 42.7% of the participants were females while 57.3% was males. The average ages of the third-, fourth-, and fifth-graders were 8;09, 9;07, and 10;11 respectively, as indicated in Table 1.

Design and Materials. There were three factors manipulated in this study: neighborhood size N1 (Large N1 and Small N1), position of target character (1^{st} and 2^{nd}) and regularity of target constituent character (regular and irregular), giving a total of eight experimental conditions (2 x 2 x 2). All the words were extracted from the textbooks of

primary three, four, and five as stimuli for third-, fourth-, and fifth-graders respectively. A list of 40 two-character compound words divided into eight groups of five according to the experimental conditions listed above was employed for each grade. All the characters were either regular or irregular phonetic compound characters. Since some phonetic compound characters such as RT (same rime-tone) were not commonly accepted as irregular or regular, they were not included in the stimuli. The eight groups of stimuli were printed on a test sheet in randomized order, preceded by five practice trials. To balance the order effect, two reading word lists (A and B) were constructed with two different word order arrangements. For example, the first 20 target words in reading word list A were positioned as the last 20 in reading word list B, vice versa. Half of the participants used reading word list A while another half used reading word list B in the reading task. The dependent variable was the number of correct responses in the reading task in terms of word.

Word frequency, component character frequency, neighborhood size, and morphological structure were controlled (see Table 2). Word and character frequencies were held constant across conditions as they were factors affecting performance in lexical access (Zhang and Peng, 1992). In this study, all the target constituent characters were of low to mid frequency, according to the Hong Kong Corpus of Primary School Chinese (Leung & Lee, 2002). The component frequency and the neighborhood size of the non-target constituent characters were tried to be held constant across all conditions. However, the control was restricted to certain extent because of the limited vocabulary size, particularly two-character compound words, for primary graders. The morphological structure of the stimuli was also controlled across conditions. There are five syntactic constructions of Chinese compound words, namely coordinative, modifier, supplement, subject and predicate, and verb and object. The contribution of the constituent character

to the word meaning varies in coordinative words and modifier or supplement words (Chen, 1996). For coordinative words, both component characters are equally important in the word meaning (e.g. 丟棄, /tiu$_{55}$/ /hei$_{33}$/, meaning "discard"). However, one component is less important in determining word meaning in modifier or supplement words. For example, "奇景" (/k^{h}ei$_{21}$/ /kɪŋ$_{35}$/, meaning "extraordinary view") is a modifier word with the second constituent character being the main morpheme and the first character being a modifier morpheme. To avoid varying importance of component characters in the compound words, the ratio of coordinative to the rest of the structures will be kept around 4:1 for every group of stimuli in each grade.

Procedure. Prior to the experimental reading test, an intelligence screening (Raven's Standard Progressive matrices) and a written reading test (Graded Chinese Naming Test) were carried out for the third-, fourth-, and fifth-graders. The students were seen for two sessions. In the first session, the students were tested on the intelligence screening, which was administered in groups. The experimental reading test and the written reading test were carried out individually in the second session.

(1) *Raven's Standard Progressive Matrices.* The test was to assess students' nonverbal intelligence. It consisted of 5 sets of 12 items. There was one target matrix with one missing part for each item and the students were required to select one from the alternatives. Those with scores 1.5 S. D. below mean were excluded from the study. The mean value of their scores was shown in Table 2.

(2) *Experimental reading test*. The students were instructed to read aloud 45 two-character compound words on the word list accordingly. The experimenter pointed to the characters on the sheet one by one and asked the participants to read them clearly. Students were allowed to skip unfamiliar characters. MP3 devices were used to record the test sessions.

Table 1: Mean Value of Ages, Raven's scores, and CNT scores of the third-, fourth-, and fifth-graders

	age	**Raven's score**	**CNT**
Third-graders	8;09	111.12	111.97
Fourth-graders	9;07	102.22	119.31
Fifth-graders	10;11	105.03	106.53

Table 2: Mean Value of Word Frequency, Component Character Frequency, and Neighborhood Size N1 of Stimuli

	Initial				Final			
	Large N1		Small N1		Large N1		Small N1	
	Regular	Irregular	Regular	Irregular	Regular	Irregular	Regular	Irregular
P.3								
Word Frequency	1.6	2	2.2	2.2	3.6	1.2	2	2
Component Frequency:								
Target constituent character	16.8	16.4	7.2	9.6	7.4	15.6	8	7
Controlled constituent character	7.8	5.2	9	11.6	2.2	4	8.2	4.2
Neighborhood Size								
Target constituent character	7.8	6.4	1	1	5.6	7.2	1	1
Controlled constituent character	1.8	0.8	1.4	0	1	1.2	1.4	1.4
P.4								
Word Frequency	1	1.6	1.6	3	2	1.2	2.4	1.8
Component Frequency:								
Target constituent character	15.9	22.6	13.8	11.2	22	20.6	4.6	9
Controlled constituent character	9.4	12.4	11.2	16.4	20	9.6	13	9
Neighborhood Size								
Target constituent character	6.2	7.4	1.4	1	5.8	6.8	1	1
Controlled constituent character	1.6	1.6	1.4	1	1	1	0.8	1
P.5								
Word Frequency	1.8	1.6	1.8	2.6	2.2	2.2	2.6	1.8
Component Frequency:								
Target constituent character	35	28.2	11	16	30.2	31.2	11	20
Controlled constituent character	10.6	14.8	18.6	15.2	12	14.4	13.4	6.2
Neighborhood Size								
Target constituent character	6.8	7	1	6.6	6.6	7.2	1	1
Controlled constituent character	1	1.2	1.6	1.2	1.2	1.6	1	1.2

(3) *Graded Chinese Naming Test*. The test consisted of 150 Chinese characters for each grade. Students were required to read aloud the characters one by one. Those scored 1.5 S. D. above or below mean were excluded from the study. The mean value of their scores was shown in Table 1.

Results

The number of correct responses was computed across participants and conditions. Both constituent characters of a compound word had to be read accurately for a correct response. For responses with only one constituent character, either target or non-target, was correct, they were not counted towards the accuracy. A three-way Analysis of variance (ANOVA) (2x2x2) with within-subject factors of neighborhood size (NS), regularity (REG) and position of target characters (FS) was performed on the naming rates.

(1) Third-graders. Main effect of neighborhood size was highly significant [$F(1, 33) = 28.12$, $p<.01$]; the reading accuracy for compound words with more neighbors sharing one of the constituent characters was higher than those with fewer neighbors. The main effect of regularity was also significant [$F(1, 33) = 11.21$, $p<.01$]; higher accuracy was found in words with regular constituent characters than words with irregular constituent characters. The main effect of target constituent character position (first VS second) was not significant, nor its interaction with neighborhood size. The interaction between regularity and neighborhood size [$F(1, 33) = 10.27$, $p<.01$] was found to be significant, indicating that neighborhood size effect was only salient when the target constituent characters were regular. Although the three-way interaction failed to reach significance, post-hoc Tukey's pairwise comparisons showed that neighborhood size effect was most significant when the 2^{nd} constituent

characters of the compound words were regular, with p <.01 (see Fig.1). Regularity effect was also most significant when the words have many neighbors sharing the second constituent characters (p<.01).

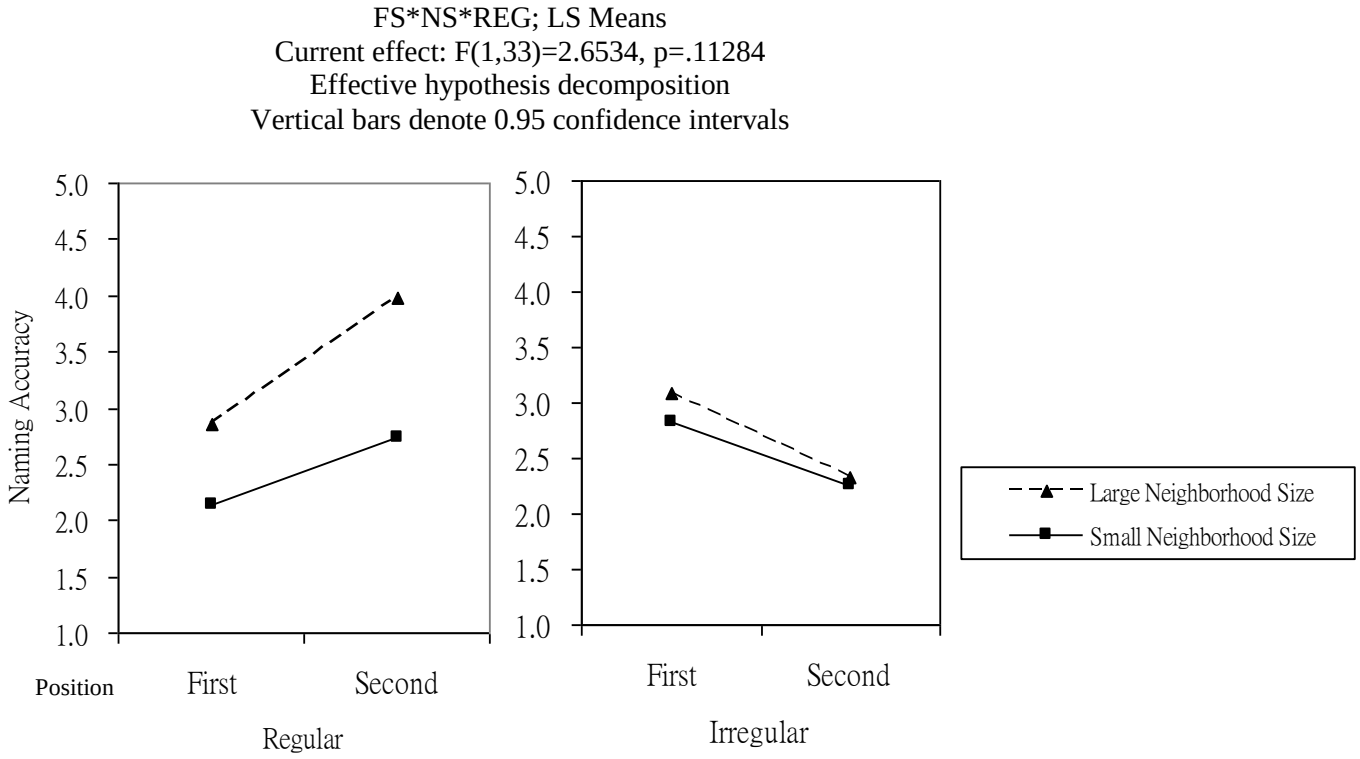

FIG 1. Interaction between position, neighborhood size, and regularity of target constituent character in reading Chinese compound words in the third graders

(2) Fourth-graders. The main effect of neighborhood size was significant [F(1, 31) =52.51, p<.01]; reading accuracy was higher in words with more neighbors sharing one of the constituent character than in those with fewer neighbors. The main effect of regularity was significant [F(1, 31) = 17.92, p<.01]; more correct responses were found in words with regular constituent characters than those with irregular ones. Similar to the result of third-graders, the main effect of target constituent character position was not significant, nor the interaction with neighborhood size. The interaction between neighborhood size and regularity was also significant [F(1, 31) =

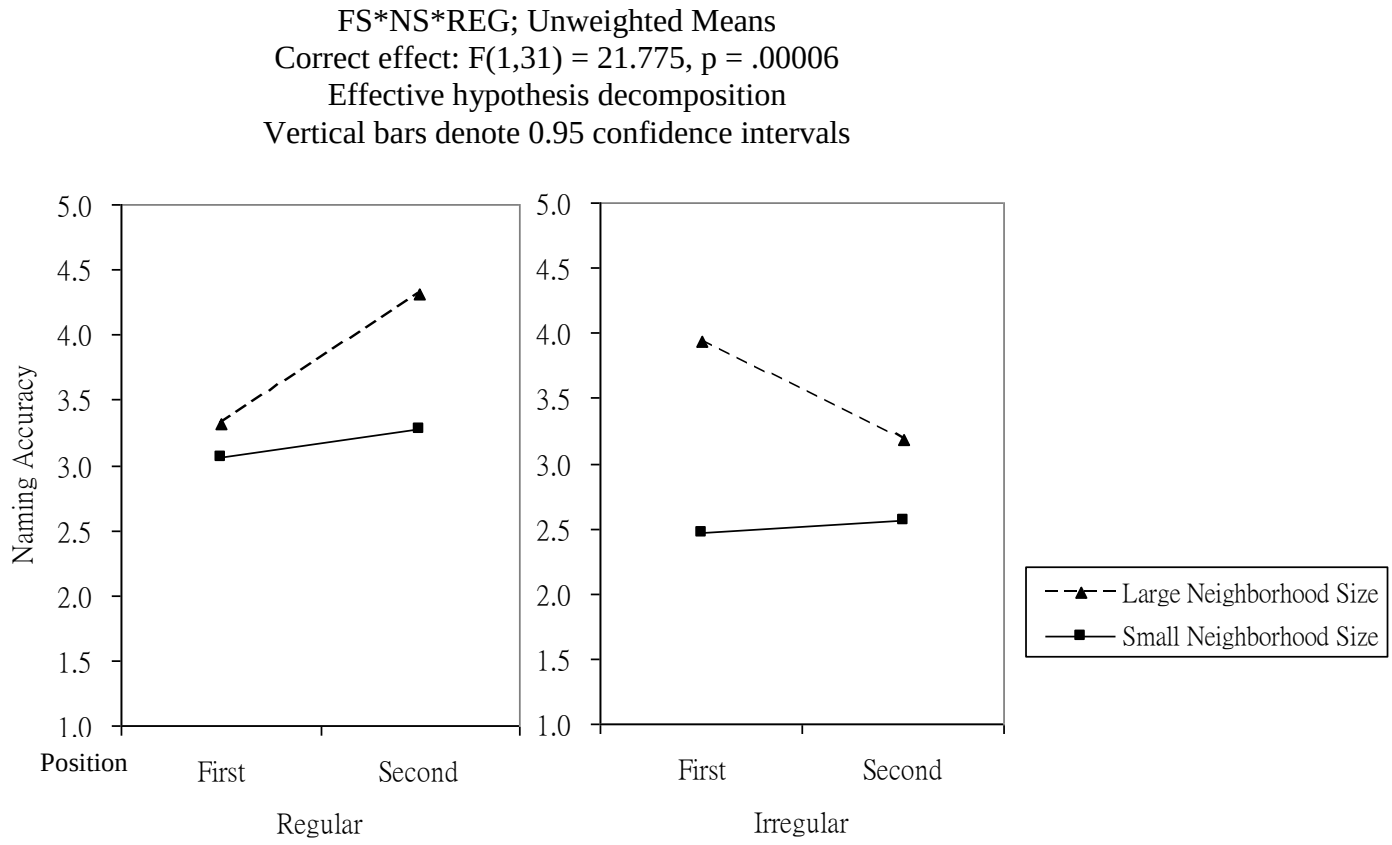

FIG 2. Interaction between position, neighborhood size, and regularity of target constituent character in reading Chinese compound words in the fourth graders

4.54, p<.05], with more prominent neighborhood size effect observed in words with irregular constituent characters. The three-way interactions were significant [F(1, 31) = 21.78, p<.01]. Post-hoc Tukey's pairwise comparisons revealed that strongest significant neighborhood size effect was found when the 1st constituent character of the compound words is irregular phonetic compound character (p<.01). The neighborhood size effect was also significant in words with neighbors sharing the 2nd constituent character which is either regular (p< .01) or irregular phonetic compound character (p<.05) (see Fig. 2). Regularity effect was most significant when the words have many neighbors sharing the 2nd constituent character (p<.01). Significant difference was also shown in words having few neighbors sharing 1st (p<.05) or 2nd, p<.01) constituent character. Negative regularity

effect was noticed in words having many neighbors sharing the 1st constituent character ($p<.05$).

(3) *Fifth-graders.* With the exception of regularity, the main effects of position [$F(1,29) = 23.20$, $p<.01$], neighborhood size [$F(1,29)= 6.37$, $p<.05$] were significant. All two-way interactions were found to be significant. They included the interaction between position and neighborhood size [$F(1,29) = 23.93$, $p<.01$], the interaction between position and regularity [$F(1,29) = 6.38$, $p<.05$], and the interaction between neighborhood size and regularity [$F(1,29) = 13.84$, $p<.01$]. More prominent neighborhood size effect was shown in words having regular constituent characters (see Fig. 3). The three-way interaction between position, neighborhood size, and regularity was also significant [$F(1,29) = 84.33$, $p<.01$]. According to the post-hoc comparisons by the Turkey test, neighborhood size effect was only significant when the 2nd constituent character of the compound words is regular ($p<.01$). Unlike the third- and fourth-graders, there was inhibitory neighborhood

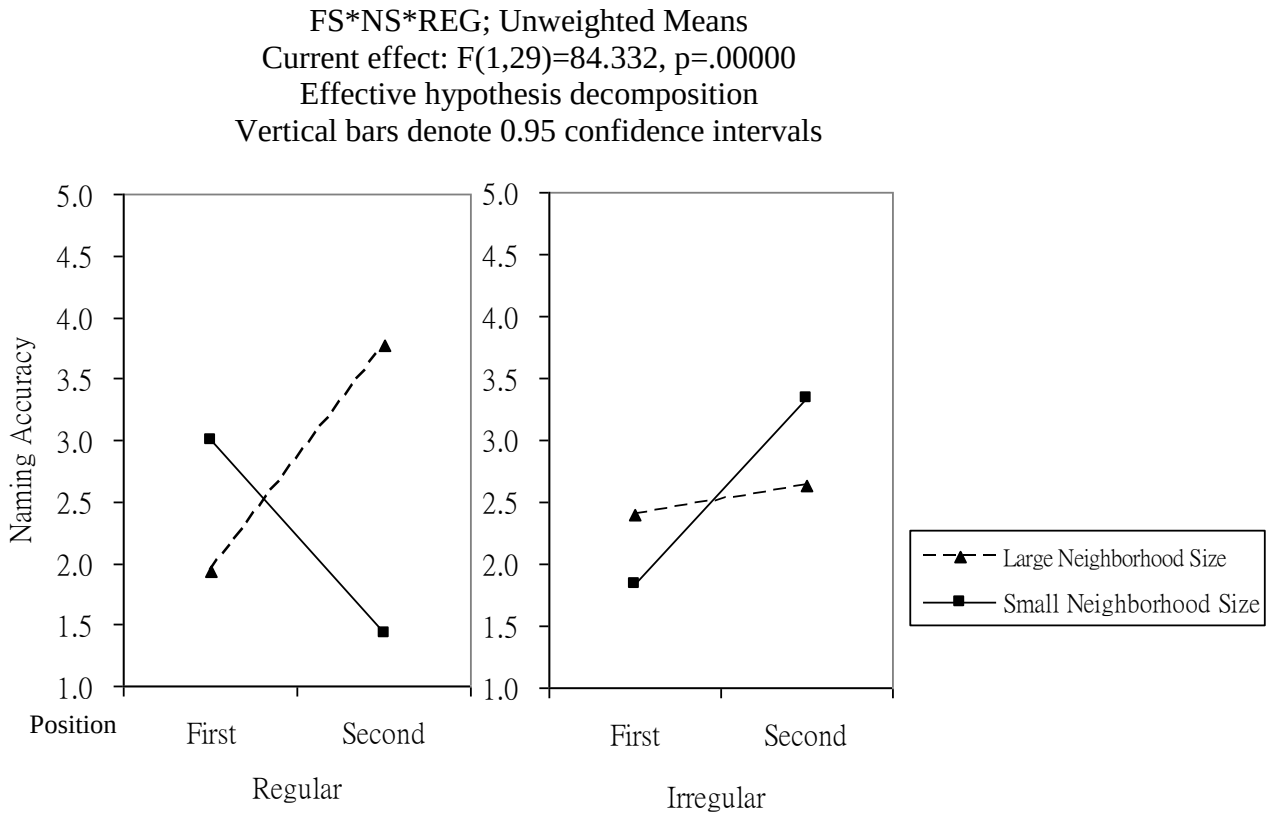

FIG 3. Interaction between position, neighborhood size, and regularity of target constituent character in reading Chinese compound words in the fifth graders

size effect for fifth-graders when the 1st constituent character of the compound words is regular ($p<.01$). For regularity effect, it was significant when the compound words with many neighbors sharing the 2nd constituent character ($p<.01$). The effect was also significant when the compound words with fewer neighbors sharing the 1st constituent character ($p<.01$). Negative regularity effect was significantly present when the compound words have fewer neighbors sharing the 2nd constituent character ($p<.01$).

(4) *Error analysis*. It was carried out at the time when inhibitory neighborhood size effect occurred in the fifth-graders. The type of errors indicating lexical competition from neighboring words was shown in Table 3.

Table 3: The type of errors that arise from lexical competition from neighboring words, with A representing the 1st constituent character of the target compound word, B representing the 2nd constituent character of the target compound word, and C representing a character that does not appear in the target compound word.

Target Compound word	Response		Examples
AB		Activated a neighbor sharing the same 1st constituent character with the target compound word	“蘇杭” → “蘇州”
	AC	The 2nd constituent character of target compound word activated a neighboring character which substituted the 2nd constituent character in the compound word	“鋪蓋” → “鋪掩”
	CB	Activated a neighbor sharing the 2nd constituent character , but with inappropriate order of characters	“躲懶” → “惰懶”
		Activated a neighbor sharing the 2nd constituent character	“躲懶” → “偷懶”
	BC	Activated a neighbor with the 2nd constituent character of the target located at the 1st position	“躲懶” → “懶惰”
	CA	Activated a neighbor with the 1st constituent character of the target located at the 2nd position	“蹤跡” → “追蹤”

Discussion

The result of the present study showed that the neighborhood size effect of Chinese compound words can significantly affect naming accuracy in local Hong Kong primary graders. Consistent with previous studies on adults (Andrews, 1989; Sears, Hino & Lupker, 1995; Tsai et al., 2006), facilitative neighborhood size effect was present in the children of the third, fourth, and fifth grades. Not only did facilitative neighborhood size be shown in lexical decision tasks, as reported in previous studies, it was also tapped in naming tasks. The result showed that reading accuracy was significantly higher for two-character compound words with many neighbors than those with fewer neighbors.

In this study, neighborhood size refers to the number of compound words sharing the same initial or final constituent character. The position of constituent character was manipulated to investigate whether the influence of neighborhood size on naming accuracy differs according to the position of the target constituent character within a compound word. For the third- and fourth-graders, the neighborhood size effect for words sharing the same initial constituent character did not significantly differ from that for words sharing the same final constituent character. The neighborhood size effect was similar under both conditions. For the fifth-graders, the position of constituent character tended to interact with neighborhood size to influence naming accuracy. Better reading performance was observed in compound words with many neighbors sharing the 2nd constituent character.

The result was against the morpheme listing view, which predicts that the first constituent character of a Chinese compound word serves as a lexical entry for the compound word to be accessed in the mental lexicon while the second constituent character is listed under the entry (Taft & Forster, 1976). The result of the third- and fourth-graders gave rise to the view that all Chinese morphemes are represented at the

same level without having primary or secondary lexical entries in the mental lexicon. The changes occurring in the fifth-graders might suggest the use of different reading strategies when compared with the third- and fourth-graders. The interaction between neighborhood size effect and position of constituent character might also be masked by the regularity effect investigated in this study. As facilitative effect of neighborhood size was not shown to be stronger in words with neighbors sharing the initial constituent characters, the hypothesis suggesting variation in neighborhood size effect across positions of constituent character was not supported by the findings.

Evidently, regularity effect plays a part in reading Chinese characters in children (Ho & Bryant, 1997; Shu, Anderson, & Wu, 2000). Chinese children are aware of the phonetic information in reading phonetic compound characters. This study confirmed the presence of regularity effect, not only in character naming, but also in reading two-character compound words. However, the regularity effect did not persist till the fifth-grade. The underlying reason could be that the children gradually realize that the information in a phonetic is not always reliable as they encounter more and more Chinese characters when they grow. Thus, a more advanced and analytical reading approach gradually develops. It might imply a change of reading strategy in the fifth-graders that they might begin to consider the family consistency information, but not solely the phonetic information, when reading phonetic compound characters. Yet, ceiling effect might be present for the fifth-graders as their reading accuracy was generally high in average.

As what have been predicted, more prominent and facilitative neighborhood size effect was shown in words having regular constituent characters in the third-graders. In the fourth-graders, facilitative effect of neighborhood size also emerged for words with neighbors sharing the same irregular constituent characters. For the fifth-graders,

facilitative effect of neighborhood size was only significantly shown in words with neighbors sharing the same regular constituent characters at the 2nd position of the compound words. Such facilitating effect persisted from the third grade till the fifth grade. These findings provided some support for the hypothesis that neighborhood size effect is more prominent on words with regular characters than in words with irregular characters. Activation of the pronunciation of irregular characters might lead to increased competition as both the phonetics as well as the neighboring characters in the same family of the irregular characters would be activated at the phonological level. Increased competition in the mental lexicon could affect naming accuracy. Since activation of the pronunciation of regular characters involves less competition at the phonological level, the interference on the facilitation effect of neighborhood size is likely to be minimized. Such effect was evident in the third-graders. However, the interaction of effects between neighborhood size and regularity changed across grades, implying the importance of regularity rules on reading in children varies across ages.

For words with many neighbors, reading accuracy did not vary a lot across grades. Dramatic changes, however, was noticed across grades when the words had fewer neighbors. Reading performance in words with fewer neighbors sharing the 1st regular constituent character improved across grades. For the fifth-graders, there was inhibitory effect of neighborhood size in words with neighbors sharing the 1st regular constituent character. Facilitating neighborhood size effect in the fourth grade was also replaced by inhibition in reading compound words with neighbors sharing 2nd irregular constituent character in the fifth grade. Unlike Tsai et al.'s study (2006) on university students, this study showed evidence of inhibitory neighborhood size effect in naming accuracy in older primary children. The possible explanation for the contrast was that the manipulation of neighborhood size effect might co-vary with the regularity of the target constituent

characters in their study. The inhibitory effect of neighborhood size could be masked by the uncontrolled regularity effect while the regularity effect interacted with neighborhood size effect to affect naming accuracy, and even response latencies mentioned in their study. With control on the neighborhood size and regularity of each stimulus, this study was able to reveal the inhibition stemmed from the interaction between these two factors.

The present study also brought out the fact that lexical competition occurred either when the first constituent character was regular or when the second constituent character was irregular. Analysis of error patterns showed evidence of lexical competition from neighboring words, contributing to the inhibition effect of neighborhood size on reading accuracy in the fifth-graders. At the time when inhibition occurred, about 21% of errors in words with many neighbors sharing 1st regular constituent character and 13% of errors in words with many neighbors sharing 2nd irregular constituent character were attributed to lexical competition from neighboring words. The error pattern implied that lexical processing of Chinese compound word involves interaction between orthographic, phonological, and semantic processing of constituent character and interaction between semantic activation of constituent character and whole words, as suggested by Zhou et al. (1999). In this study, the findings supported the hypothesis that the representations of the target compound words are activated together with their neighboring words or characters, which are activated partially, in the mental lexicon of the primary children. The involvement of partial activation of neighboring words is proved to be facilitative to naming accuracy.

Yet, the inhibitory effect of neighborhood size observed in the fifth grade indicated the possibility of excessive lexical competition in the mental lexicon. Instead of being partially activated, the neighboring words and characters are fully activated; leading to misidentification of target words as semantically or even phonologically related

neighboring characters or words. Different from the neighborhood of English words defined by N, semantic similarity is a specific feature of the neighborhood of Chinese words (Tsai et al., 2006). Since the semantics of the constituent characters are often transparent to the meanings of the compound words, the semantics of the neighbors is also likely to be similar or related. Thus, large neighborhood size might cause strong activation on a large number of semantically similar candidates, increasing lexical competition at the semantic activation level as well as the possibility of faulty lexical selection. Such findings, however, give rise to another question of what the potential threshold for neighborhood size should be in order to be facilitative in lexical selection but at the same time not causing the unresolved conflict from excessive lexical competition at different levels in the mental lexicon. The inhibition might also imply a competitive interaction between the activation of neighboring words at the semantic levels and the regularity effect at the phonological level. The regularity and neighborhood size effect might struggle at different levels in the mental lexicon to affect reading accuracy.

The inhibitory effect of neighborhood size was only prominent in the fifth-graders. It might suggest a developmental change in reading across grades. One possible reason is that the fifth-graders have increased exposure to Chinese words. They are supposed to have a larger repertoire of Chinese words in their mental lexicon when compared to younger graders. It is because children of higher grades typically encounter more words sharing similar semantic meanings or even similar phonological representations, which may or may not be the neighboring words. Due to the increased frequency of occurrence of each lexicon, more candidates will be partially activated in the mental lexicon when reading. Thus, the conflict and lexical competition is likely to be more pronounced in order children, increasing the chance of misidentification of orthographically or

phonologically similar words. For example, the character “棒” (/$p^{h}aŋ_{23}$/, meaning “stick”) could be misidentified as orthographically similar character “捧” (/$pυŋ_{35}$/, meaning “holding with hands”) and character such as “略” (/$lœk_{2}$/, meaning “sketchy”) could be recognized as phonologically similar character “落” (/$lɔk_{2}$/, meaning “fall” or “drop”). With a smaller repertoire of vocabulary, Children of lower grades are likely to have less lexical competition during activation of target words.

There were several limitations for this study. The consistency and family size of the constituent characters used in the experiment, as well as the concreteness of word meanings, was not held constant across all conditions. The uncontrolled consistency and family size of the constituent characters may hinder or foster the use of consistency rules in the naming task. The concreteness of the word meanings is another extraneous variable that may potentially affect the naming responses. Yet, the values of the concreteness and consistency of the stimuli did not show any extreme variation that could explain the significant findings. Little variation in consistency values was found in the stimuli across grades, which did not support the significant differences and changes of neighborhood size and regularity effect in different grades as shown in this study. Thus, despite of these possible confounding factors, the extraneous influence was not great enough to hinder the result and so the conclusion above still holds.

To summarize, this study demonstrated that neighborhood size effect was facilitative on naming accuracy of Chinese compound words in primary graders. Inhibitory effect of neighborhood size was also evident in certain occasion, when the neighborhood size interacted with the position and regularity of the target constituent characters. It was hypothesized that the threshold for neighborhood size and the competition between the regularity effect and the neighborhood size effect at different levels in the mental lexicon determines how the neighborhood size contributes to the

naming accuracy. Further research will be warranted to investigate if there is a threshold for neighborhood size effect to be facilitative.

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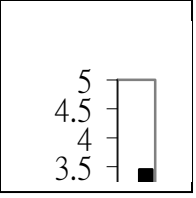
Appendixes

The word list used in the experimental reading test

	Initial				Final			
	Large N1		Small N1		Large N1		Small N1	
	Regular	Irregular	Regular	Irregular	Regular	Irregular	Regular	Irregular
Third-graders	優裕	銀盤	燃燒	羞愧	澳洲	概念	痕癢	蕃茄
	翻鬆	貪慕	愉悅	寂寞	魔術	縫針	召喚	元宵
	伸縮	偷懶	磚洞	割損	煉奶	堤岸	含糊	嬌嫩
	湖泊	籌措	叮囑	震盪	銷案	稻粒	挨飢	澄碧
	依靠	枯萎	痊癒	蕭邦	描述	鋪蓋	螳螂	砍柴
Fourth-graders	靈魂	粗俗	叮囑	浩瀚	揭幕	堤岸	泡沫	坑穴
	躲懶	銀盤	嗚咽	核桃	敍述	概略	痕癢	障礙
	湖泊	偷懶	菠蘿	羞愧	淚珠	鋪蓋	吞噬	澄碧
	蘇堤	浮雕	磚洞	泄洪	煉奶	蹤跡	蟑螂	批准
	蒼翠	枯萎	撕碎	彌補	錢袋	狀波	儲蓄	稚嫩
Fifth-graders	蘇杭	貪慕	蓬勃	晃蕩	揭幕	鋪蓋	撒謊	批准
	靈魂	遺址	側翼	牌坊	敍述	蹤跡	迂迴	曝曬
	躲懶	宣泄	崗亭	哀愁	皺紋	概略	吞噬	烹調
	俯瞰	籌措	捲鬚	顛簸	煉奶	狀波	碉堡	詼諧
	漂泊	碎屑	懊悔	奢侈	瀰漫	哨棒	綢緞	澄碧

The consistency values oft the stimuli used for the third-, fourth-, and fifth-graders

	Initial				Final			
	Large N1		Small N1		Large N1		Small N1	
	Regular	Irregular	Regular	Irregular	Regular	Irregular	Regular	Irregular
Third-graders								
Target	1.8	4.6	3.4	1.8	1.6	3.6	1	3.8
Controlled	(3)	(2.6)	(2.8)	(2.6)	(2.6)	(2)	(2.8)	(2.4)
Fourth-graders								
Target	1.6	5.2	3.2	2.6	2.4	5.4	1.2	4.4
Controlled	(3)	(3)	(2.4)	(3.8)	(3.2)	(2.6)	(4.2)	(4.8)
Fifth-graders								
Target	1.6	4	2.6	4.8	2.8	4.4	1.4	5.8
Controlled	(2.8)	(4.4)	(3)	(4)	(3)	(3.8)	(3.2)	(2.8)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3.5